Leonard C. Wason

CONCRETE CONSTRUCTION FOR MILL BUILDINGS

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By Leonard C. Wason, C. E.

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Concrete Construction for Mill Buildings

A Paper Read Before The National Association of Cotton Manufacturers at its Ninety-eighth Meeting, Boston, Mass., April 29, 1915.

FOUNDED 1854
INCORPORATED DEC. 1, 1894

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Concrete Construction for Mill Buildings.

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It is the desire of the writer to present to you, without tedious detail, the advantages of concrete, plain and reenforced, as applied to the cotton industry. He wishes also to point out some of the safeguards necessary, and to suggest a few uses to which it is not so perfectly adapted as some other material may be. The literature on the subject is very extensive, going into much detail as regards strength of materials, methods of design, etc. Those who wish can find literature covering almost any special point on which detailed information is desired.

In preparing this paper the writer has endeavored to answer very briefly those questions which are naturally asked by an executive who is considering construction work. Many of these are answers to actual questions. They are given without any attempt at detail, or any attempt to indicate the steps leading up to them.

THE CONCRETE BUILDING HAS PLENTY OF LIGHT.

The first use which comes to mind is the larger buildings of a manufacturing plant. One advantage of reenforced concrete in the construction of the principal mills is that small wall columns can be used, permitting very large window areas, so that light is uniformly distributed throughout the length and width of the rooms. The usual design today is the girderless floor, which gives a flat ceiling so that there is no obstruction to light, and the wall beams are above the floor line instead of below. This permits the window frames to reach the ceiling, so that the glass may be within an inch and a half of the ceiling level. The wall beam forms in part the curtain wall between the floor line and the window-sill. As daylight is cheaper than artificial light, and as metal framed windows with wire glass are as cheap as masonry curtain walls, there is a saving in first cost of construction, and a saving in operation, due to the illumination. While there is more radiation of heat from the glass area, there is less leakage, due to the tightness of the metal sash, and probably not much difference in cost of heating the building.

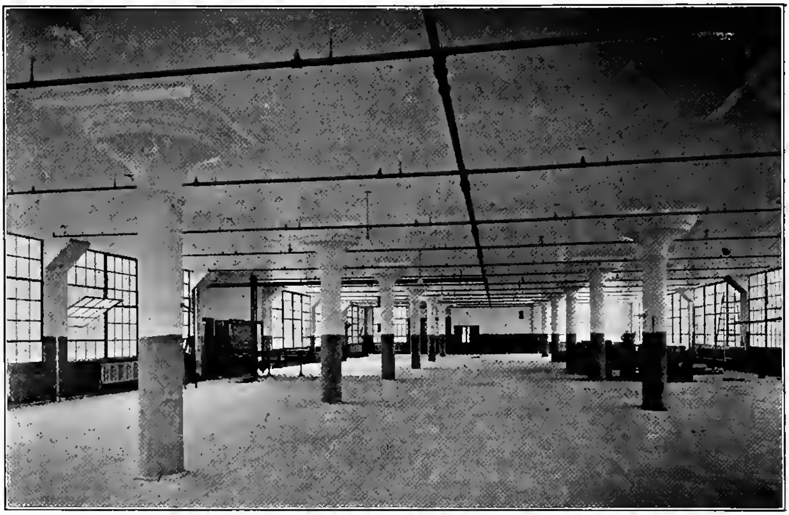

FIGURE 1.—MUSHROOM FLOORS, ALSO METHOD OF ATTACHING PIPING TO CEILING BY MEANS OF INSERTS, ALSO LOCATION OF WINDOWS CLOSE TO CEILING.

FREEDOM FROM VIBRATION.

In buildings where there is reciprocating machinery, like looms, all working together, and whose moving parts have a uniform speed, there is a large advantage in concrete, because the greater solidity and rigidity of this floor over that of any other type absorbs this vibration in the same way that a heavy foundation absorbs that of a horizontal reciprocating engine. Aside from freedom from damage to the building by this vibration are the stability and free running qualities of the machines themselves. This adds to their life and reduces the possibility of breaking the threads, which affects the cost of operating and the quality of the product. It has been found by some manufacturers that looms can be run 15 percent. faster on a solid concrete floor than on a wooden floor subject to vibration. It has also been found that, due to the rigidity of the floor, there is a distinct saving in power.

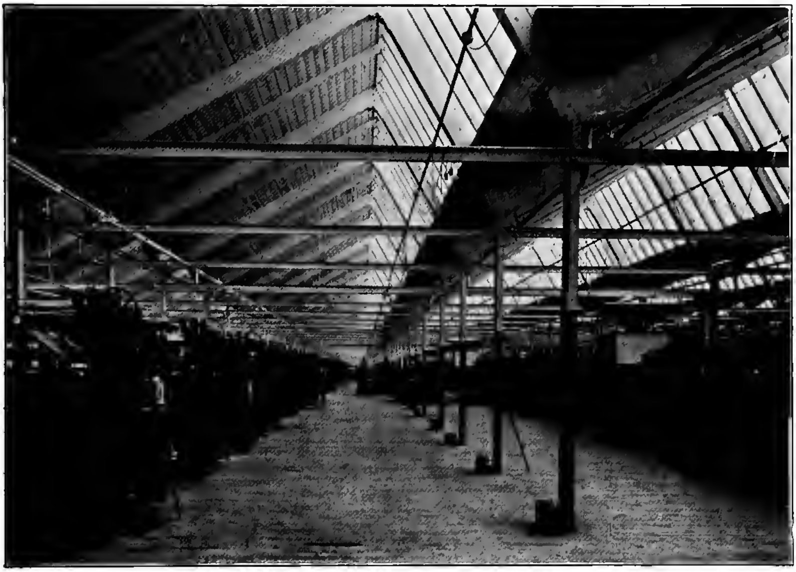

FIGURE 2.—THE WOOD FLOOR OF THIS WEAVE SHED IS LAID ON A HEAVY CONCRETE FLOOR. THE RIGID CONSTRUCTION HAS MADE IT POSSIBLE TO RUN THE LOOMS AT HIGH SPEED.

This makes concrete very advantageous for the weave sheds, and the construction of a concrete sawtooth roof, when properly studied out, is not much more expensive than one of wood, while it has advantages over wood besides that of fireproofness. The additional material necessary in building a floor for a heavy load, over the minimum which must be used in even a light floor, is relatively small; so that floors carrying heavy loads, as in a storehouse, are cheaply obtained. It is also an easy matter to render the floors and walls so dense, by the proper proportioning and placing of the concrete, as to be waterproof. This makes the material admirably adapted for use in such wet places as dyehouses, where water and steam are freely used. It is an easy matter and relatively inexpensive to make the floors water-tight and to pitch them to drains, so that water can quickly be removed from their surface and the floor below guaranteed against damage from leakage.

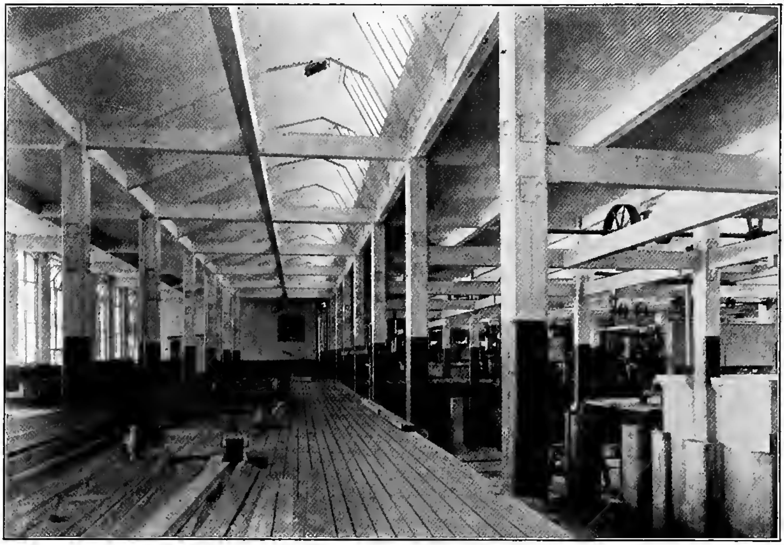

FIGURE 3.—CONCRETE SAWTOOTH ROOF IN PACIFIC MILLS, ALSO CONCRETE COLUMNS AND GIRDERS. THIS SHOWS BOLTS LEFT IN CONCRETE COLUMNS FOR FASTENING WOOD INTERMEDIATE TIMBERS, ALSO PIPING AND SHAFTING.

The resonance of a concrete floor is sometimes a matter of importance, though modern design has practically done away with it. In some of our earlier beam and girder construction very thin sections were used. In one building there were three-inch floors and three-inch landings on the stairs — both about as resonant as a drum head. Today much heavier sections are used, with wider spacing of beams, and the greater mass absorbs the sound. Instead of three-inch thickness, it is becoming the custom to use five or six inches. If something must be especially sound-proof, there are various methods of building a dead air space.

Concrete is, however, a better conductor of heat than wood, so that for external walls or roof of a dye-house it is desirable to have a dead air space or some other form of non-conductor to prevent condensation. To prevent condensation on windows, it is desirable to have a double-glazed sash and sometimes a triple thickness. But the design of the sash or frames should permit the separation of the sash for cleaning the glass, as it has been found impossible to fit these so tightly together as to prevent ultimate clouding of the glass in the space.

Because of the conductivity of concrete, it is often necessary in dyehouses, and other places where condensation is bad, to use insulation. This is sometimes felt quilting made of seaweed paper; sometimes it is porous cinders, sometimes cinder concrete or hollow tile. Some device of this kind, when necessary, is not expensive.

CONCRETE FOR BOILER FOUNDATIONS.

In the steam power plant, concrete can also be used to very good advantage, not only in the building itself, but for boiler foundations. Especially where the ground is soft and of uneven bearing capacity, concrete is unexcelled, because a reenforced mat can be put over the whole area, so that the boilers are practically floated on their foundations. It is not advisable, however, to use concrete higher up for a boiler setting, although in isolated cases this has been done. Brick is better adapted to this purpose. Concrete is liable to shrink and open large cracks through the setting, which would permit the escape of gases. These cracks, being difficult to fill thoroughly and permanently, are objectionable.

Although concrete will withstand for an indefinite period a temperature of 500 degrees Fahrenheit, a temperature of 800 degrees or more will ultimately disintegrate it. It is thus not a proper material to be used in the fire box, or where temperatures are high. The writer knows of special cases where concrete, using crushed fire brick for coarse aggregate, and as sand the finer particles of fire brick, has been in use in furnace construction for several years without deterioration. He does not consider, however, that a few isolated examples of this are sufficient to prove its general adaptablity for such purposes.

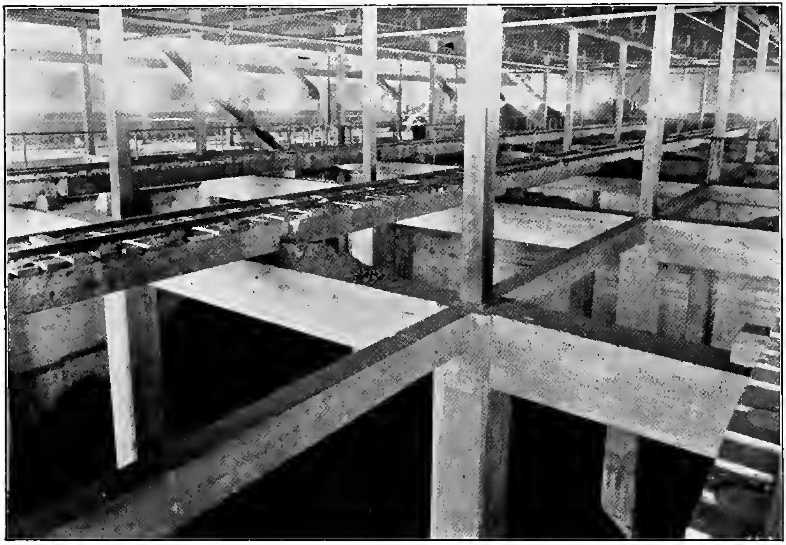

FIGURE 4. — INTERIOR OF 10,000 TON COAL POCKET AT PACIFIC MILLS.

CONCRETE CHIMNEYS.

By the time the burning gases from a boiler reach the chimney, however, the temperature is such that no damage is likely to ensue, and chimneys can be easily and cheaply built of reenforced concrete. Instead of a heavy gravity construction as is

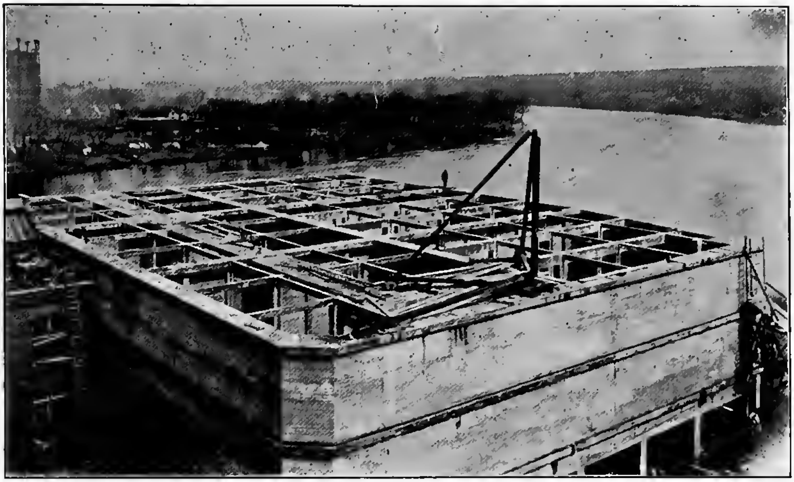

FIGURE 5.—CONCRETE COAL POCKETS, HOLDING 10,000 TONS OF COAL, PACIFIC MILLS, LAWRENCE, MASS.

used with brick, the design is that of a broad base and vertical shaft, tied rigidly together so as to be a unit. Thus the chimney might be compared to a candle, which by itself is unstable, but when set in a candlestick the combination cannot be readily tipped over.

Chimneys are built with various details of design, all of which have proved stable and durable. For ease of construction, the shaft is made of a uniform diameter from bottom to top, which gives the chimney a somewhat top heavy appearance as compared to the tapering brick chimneys with which we are so familiar, and to which our eye is educated. This type of chimney can be built more quickly than one of brick, and can be put into service as quickly after its completion. The reason so many are built of concrete is their low first cost. Some concrete chimneys have failed, due to the use of dry concrete. Those made with wet concrete have proved satisfactory.

COAL POCKETS OF CONCRETE.

Another use in the power plant is for coal pockets. There are a number of elevated pockets holding a depth of 40 feet of coal, a pressure of over a ton to the square foot, and the material can be economically designed to carry these loads. Even should spontaneous combustion occur in a compartment, it need not necessarily destroy the pocket. Though the burning coal creates a considerable heat, it can either be drawn out or flooded with water before injury to the pocket occurs, while a wooden pocket would be wholly destroyed. From past experience, the writer has found that the first cost of such a pocket is about ten percent. more than that of a wooden one. Its life is much longer.

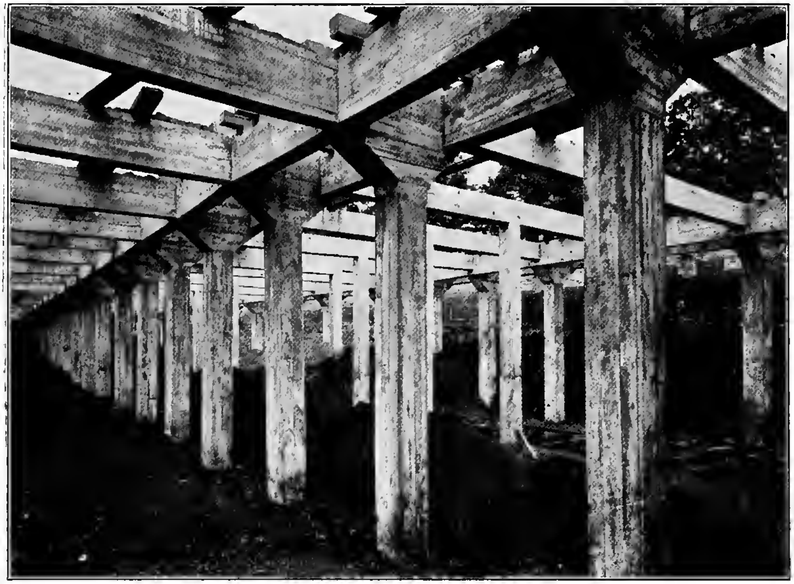

FIGURE 6.—REENFORCED CONCRETE COAL POCKETS CARRYING RAILROAD TRACK OVERHEAD, JACKSON CO., NASHUA, N. H.

For engine foundations, plain concrete is now almost universally used. It has greater weight per cubic foot than brickwork, it is more quickly and more cheaply placed, and both tests and experience have proved that it is immune from deterioration by the lubricating oil inevitably spilled upon it.

SURFACE TREATMENT OF CONCRETE.

Before dropping the subject of buildings, attention should be given to the treatment of exterior surfaces. The simplest and cheapest treatment is to rub the surface, soon after the forms are removed, with a coarse carborundum stone, cement, fine sand and water. This fills up the voids, if any, and removes fins, giving a uniform texture but not necessarily a color. On the final cleaning down of the building, rubbing with carborundum and water gives a uniform color, that of the cement, and therefore permanent. This is a clear gray and of itself is not very pleasing.

A tint can be obtained by the addition of coloring matter

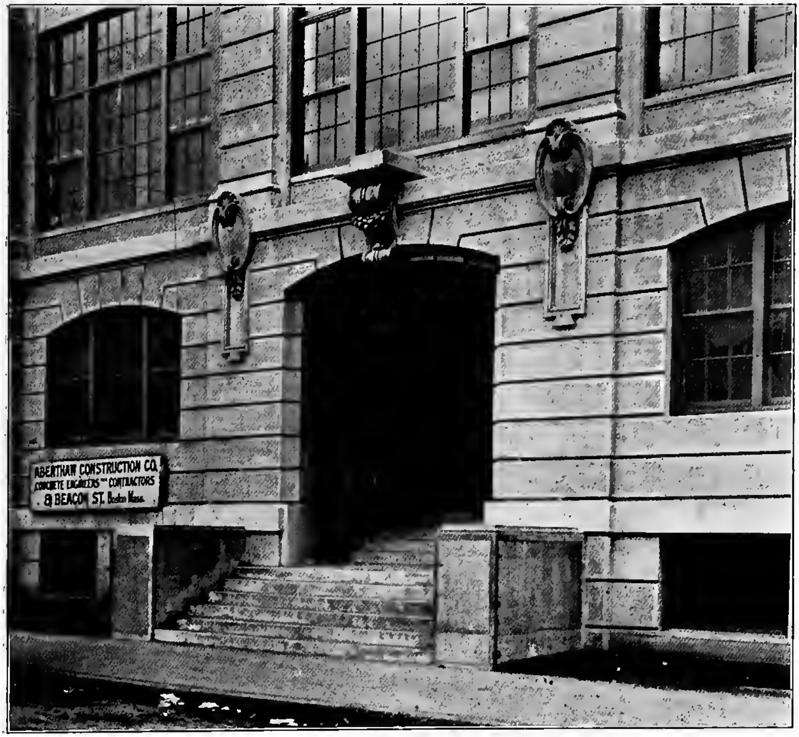
ABERTHAW CONSTRUCTION CO.
CONCRETE ENGINEERS — CONTRACTORS
8 BEACON ST. Boston Mass.

FIGURE 7.—ORNAMENTAL PIECES CAST SEPARATELY AND PLACED IN BUILDING.

which has a strong contrast with the cement itself, preferably a lamp black or deep red in small quantities, and with colored sand. A warm pleasing tint, such as is found in Indiana limestone, can be obtained without very much expense. A color contrast by the use of red brick for curtain walls and for corner piers makes a very attractive building.

Concrete can be tooled in various ways, as is the natural stone, so as to expose the coarser aggregate of which the concrete is made; and some types of mouldings can be made without serious increment of expense. The cost of ornamentation comes chiefly in the form work. Because the material is plastic, it is easy to fill forms, whether they be plain or ornamental. A mill built several years ago in an adjoining city had a very ornamental front, with ornaments cast in individual moulds, and set, as natural stone would be, around the main entrance and in the cornice above. The difference in cost between this design and the conventional mill construction was less than 2 percent. of the total cost of the mill.

CONCRETE DAMS AND RESERVOIRS.

Equally important with the use of concrete in connection with steam power is its use in connection with water power development. In the development of power from the fall of water in a river, the integrity of the investment depends upon the stability of the dam which impounds the water. The head that can be secured and the nature of the foundations are the controlling factors. Different types of dams have been designed, each of which may be most advantageous in a given situation, but none of which is recommended as being adapted for every position.

With any type of dam, the best time to begin construction is usually in the middle of the winter. Transportation is less expensive over the snow; the low condition of the river is usually favorable to the building of the initial cofferdams; the necessary preparation in the assembling of construction tools and machinery, and the bringing together of the construction force, etc., can better be done at this season. It should be noted that in every hydraulic installation there is a great deal of work that is per-

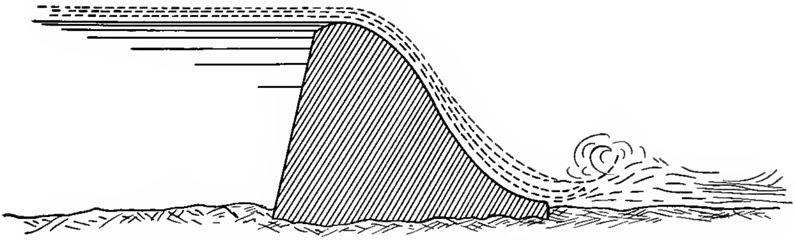

FIGURE 8.—SECTION OF SOLID WEGMAN DAM WITH APRON FOR THROWING THE OVERFLOW WATER HORIZONTALLY INTO THE LOWER PART OF THE RIVER.

formed outside of the river bed. If all this is done before the spring floods have passed, the remainder of the season is usually sufficient time for the completion of almost any structure, excepting one of uncommon magnitude.

TYPES OF CONCRETE DAMS.

For a solid rock foundation with a 30-foot head or less, the

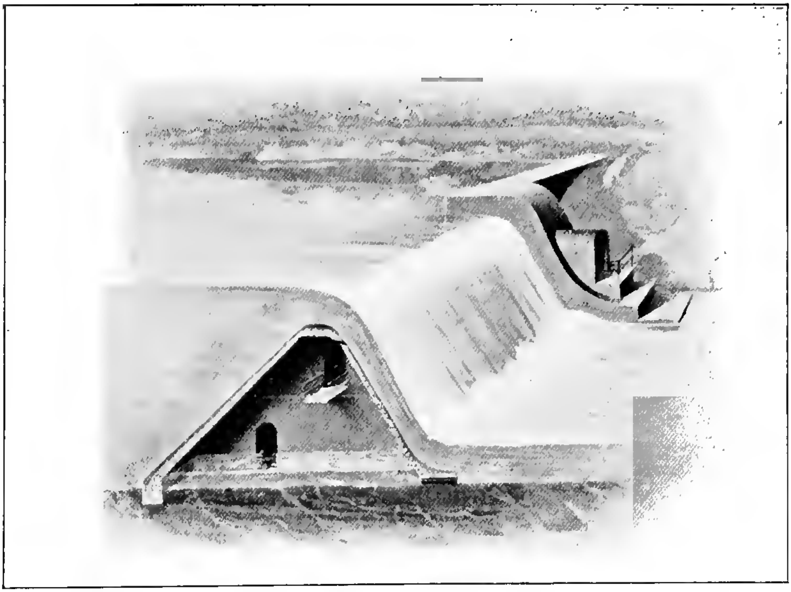

FIGURE 9.—SECTION OF AMBURSEN APRON DAM FOR ROCK FOUNDATION AND HIGH HEAD.

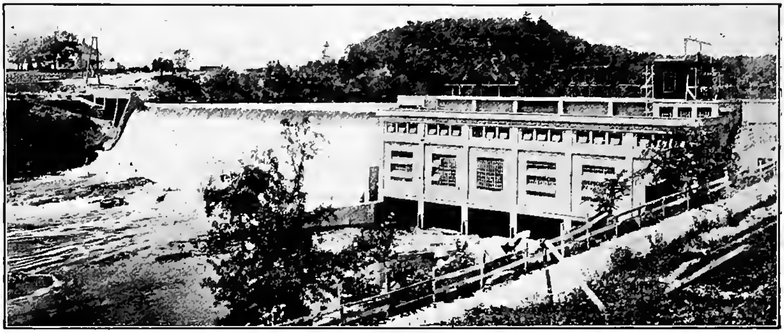

FIGURE 10. — AN EXAMPLE OF POWER HOUSE BUILT RIGHT INTO THE DAM.

standard Wegman section of solid concrete, in which a large amount of displacement stone may be used, is the prevailing type, and is lowest in construction cost. When the head is as great as 50 or 60 feet, some other type should be considered, in view of economy. At a height of 100 feet, unless there are other predominant factors, the solid section is the most expensive. In the hollow cellular dam of reenforced concrete, the buttresses or piers, spaced from 12 to 20 feet apart, are connected on the upstream face with a flat slab of reenforced concrete, designed to support the necessary load. This type minimizes the amount of material used in construction, — an important factor when the transportation of cement, stone and other materials is a serious item of cost.

A third type,— another cellular dam,— combines the ideas of the two described, namely, the wide spacing of the buttresses and the arching of the upstream face, with the object of diminishing the amount of material used. This is done by the introduction of a moderate amount of reenforcing steel, at the same time diminishing the amount of construction work by the building of fewer piers or buttresses. On a rock foundation, if the dam is less that 30 feet high, the solid section Wegman type with displacement stone usually costs less. At 50 feet a cellular gravity dam will effect a saving of perhaps 10 percent; at 75 feet it will perhaps cost 20 percent less, and at 100 feet the cellular dam will probably cost 30 percent. less than a solid section. These figures are very approximate.

It is where the foundation is not on solid rock that the greatest variation in types of dams exists. Dams have been built upon sand or clay, gravel or mud, and have successfully performed their functions. Very seldom is it necessary to abandon a site altogether, through inability to design a dam which will be absolutely stable and sufficiently low in cost to justify the investment.

Electrical engineers have so perfected the transmission line that it is no longer necessary to build a mill by the site of a dam. Neither is it necessary to have long flumes and canals, unless to utilize the fall of the river below the dam and thus obtain additional head, which sometimes cannot be secured except by this method.

SECONDARY POWER OF A RIVER.

In the use or the sale of electrical energy, the secondary power of a river is today a great advantage to the investment. For that reason the power house constructed in the dam is today provided with an excess of generating machinery, so that in times of high water more of the power of the river can be utilized. Studies of generating machinery and the economical load factor of production have shown that, in some markets, generating machinery used for only sixty days in the year well repays the cost of the installation. For this reason, careful study of the river flow, the number of floods or partial floods that may be anticipated, the question of the further development of the river, and the conservation of its head waters, all should be carefully considered. Only then should the amount of the generating machinery be determined upon, or all of the space in the power house allotted, with no provision for further enlargement.

If possible, canals, flumes and penstocks should be avoided, as they restrict the amount of water that can be utilized, and usually confine the generation to the primary or minimum flow of the river, whereas the secondary flow is often today of greater importance. It has been demonstrated that a varied power market combining night and day users of electrical energy will absorb practically all of the secondary generation. Many manufacturing firms that have installed a hydro-electric station merely for their own use, have found that surplus power was not only a source of added income, but an added means for the upbuilding of the community.

The power house constructed in the dam can be designed to utilize a large portion of the flow which would otherwise be wasted. The power house at the end of a canal or flume can use only the water which this canal conveys to it. There is a nice balance between the amount of money to be invested in canals and the proper conservation of the entire power of the river; and the possibility of future storage has to be considered. The power house in the dam will usually be the most economical

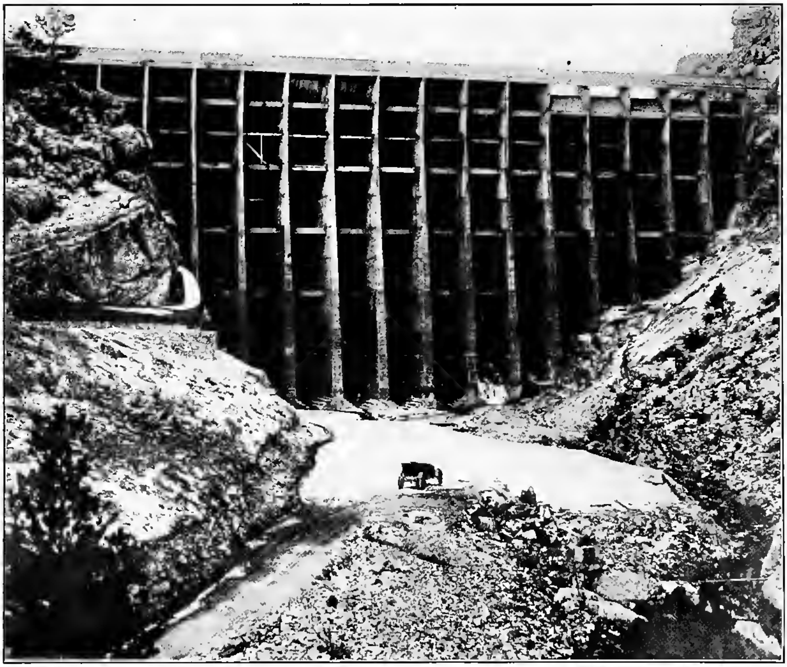

FIGURE 11.—DAM OF CELLULAR CONSTRUCTION, 135 FEET HIGH.

in construction, as it minimizes both the amount of concrete and the quantity of excavation.

The low head, open flume construction is most expensive, as regards both the building and the generating machinery; and as a rule, the higher the head, the less the cost per kilowatt of complete generating station (considered by itself). A great advance has been made in the adoption of various types of turbines under fluctuating heads and under low or high pressure, and often the type of turbine determines the design of a power house. It is manifestly out of place in a paper as brief as this to discuss the design of various types of dams, power houses, and of the generating machinery installed therein.

CONCRETE FOUNDATIONS.

Big block stone is seldom if ever used today for foundations. Concrete, being strong and improving in strength in moist places instead of deteriorating, has become practically universal. Where the ground is firm, the problem is simple. Where the ground is of moderate bearing capacity, it is very easy, by reenforcing, to spread the load over a wide area, with an increase in depth of not over one-third the spread, thus materially saving in excavation. The same is possible with interior piers, by reenforcing the footings in two or more directions. Where the ground is too soft to carry this load, but for a short time will hold its position without slumping, a special form of pier can be used conveniently. A cylinder of thin sheet metal is sunk, the material excavated inside it, and when the solid bearing stratum is reached, the soil is scooped out horizontally so as to increase materially the bearing area. The chamber thus formed is immediately filled with concrete.

In a soil which would not stand more than a half hour by itself, it is possible to increase the bearing area on the ground sufficiently to develop the full strength of the concrete pier. This method may be used for piers 15 inches and upwards in diameter and of lengths up to 20 feet. Concrete piles of various types have been used to good advantage. Some are cast in place, having first driven a shaft to make a hole in the earth, and then used the earth as a form. Again, a steel core is driven with a thin sheet metal covering which is left in place and filled with concrete. Some concrete piles are cast on the surface of the ground, permitted to harden, and then driven like a wooden pile.

The carrying capacity of a concrete pile is equal to three wooden piles. Where the ground water level is low, which would require cutting off wooden piles at a considerable depth below the surface of the ground, capping them and building a pier above, concrete piles can be used to good advantage and with economy, because they are brought to the under side of the cellar floor. They thus save in the excavation and masonry necessary to cap the wooden pile.

If it is found desirable to add to the height of a building, and the foundations are inadequate to carry the additional load, they can without much difficulty be underpinned in sections with reenforced concrete. In this way a broad spread can be made as previously described, and with very little excavation. When a short section has sufficiently set, an adjoining section can be opened out and the process repeated, until the whole building is reenforced, when the additional load can be placed upon it.

It is possible also to place concrete safely under water, even at a great depth, if proper precautions are taken and the water is kept still until the cement sets.

WATERPROOFING CONCRETE ROOFS.

The use of concrete for roofs has simplified the waterproofing problem. Instead of using 5-ply roofing paper, 3-ply will be found ample. The saving from this source often exceeds 2 cents per square foot, or $600 on a mill 75 by 400 feet. The two extra plies used on a wood roof are needed to make a smooth surface, but the concrete roof is already smooth.

For a picker room, concrete is especially well adapted. It not only makes a room which is fireproof in itself; but it forms a tight surface, through which lint cannot be blown by the pressure of the fans. The contrast in this respect with a wood floor is very marked, as those who have been annoyed by lint hanging down from the ceiling of the room below the picker room can well testify.

MINOR TEXTILE USES OF CONCRETE.

Some of the minor uses for concrete in the cotton industry are for tanks for holding clear water or liquors of various kinds. It is an easy matter to make a tank of the size which is used in wood, and guarantee it water tight in concrete. But it is necessary to use great care in proportioning the sand, stone and cement to get the maximum density, to use the right proportion of water, and carefully to mix and place the materials. Then the concrete is really water tight.

For tanks to hold chemicals or dye stuffs, the user must consider whether or not these chemicals will attack the tank itself. As the base of Portland cement is lime, acid will attack it. If the concrete is porous, and the tanks are alternately emptied and filled, even alkalies will destroy it, due to the crystallization of the alkalies within the pores, which mechanically disintegrates the concrete. Such cases have come within the writer's personal

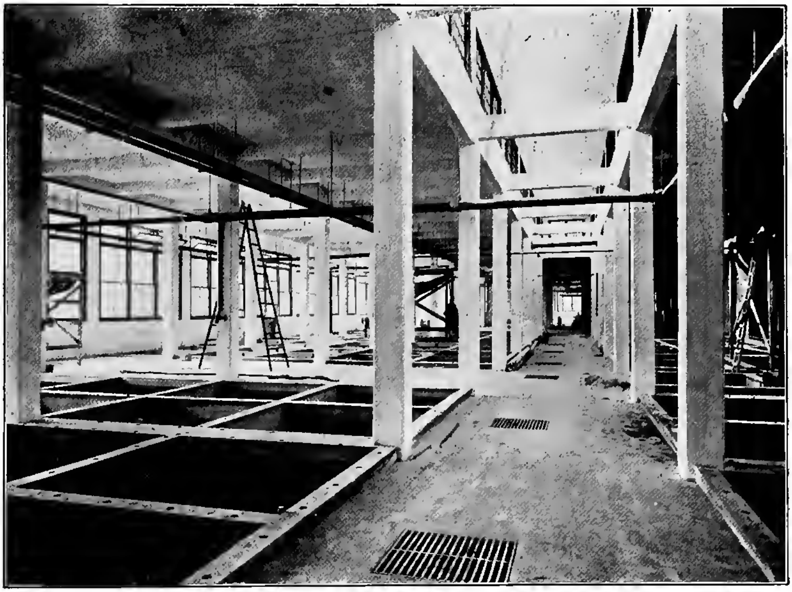

FIGURE 12.—CONCRETE TANKS BELOW FLOOR; CONCRETE COLUMNS; CONCRETE BEAM AND GIRDER SYSTEM SUPPORTING CONCRETE ROOF.

experience. When a tank is new there is a little free lime on the inside surface, which may temporarily affect the solution in the tank, because of the solubility of this lime, but this will disappear after some weeks of service. This must be kept in mind if the nature of the solution is such as to be injured by lime.

Other uses are for filter beds in the filtering of water for manufacturing purposes, and for reservoirs for the storage of water for fire and other uses. Standpipes, due to their size, are

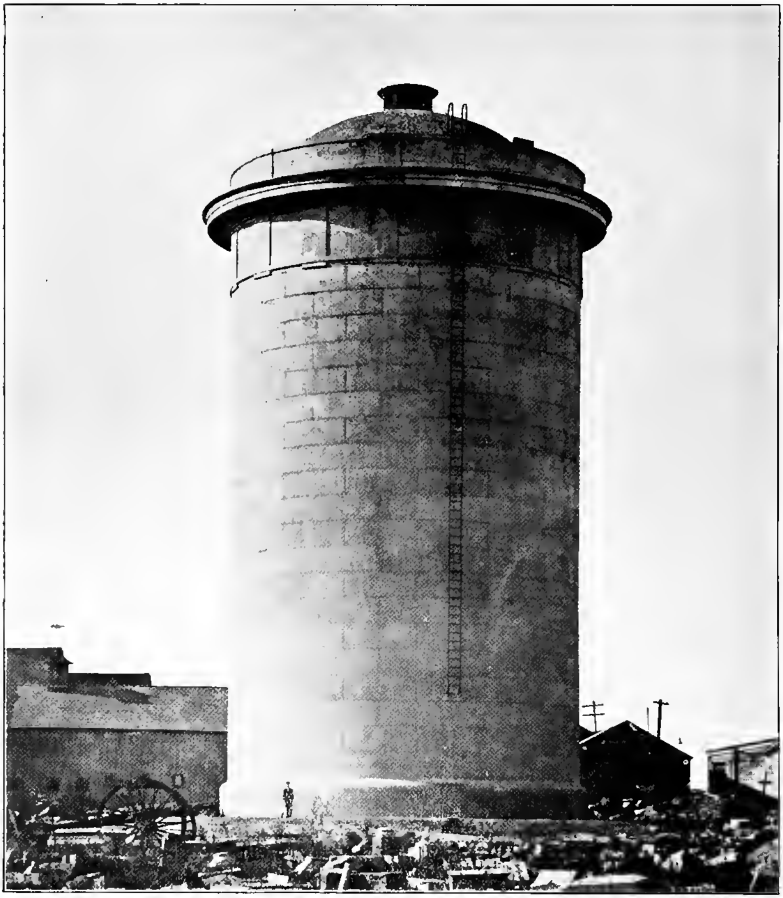

FIGURE 13.—REENFORCED CONCRETE STANDPIPE AT WESTERLY, MASS.

very difficult to make absolutely tight in reenforced concrete. To accomplish this result, an impervious lining of some kind must be used.

Another use to which concrete has been put to a limited extent is for cloth pits in bleacheries. Here the result to be obtained is a surface so smooth that no injury will be caused to the most delicate fabrics, and yet so hard that no particle whatsoever will rub off and be mixed with the fabric, which later has to go through other processes, such as dyeing or printing. This type of pit requires special construction to obtain these results. In a recent plant of large size, a number of pits of this type were used, even at considerable increase in cost over wood. Except where heavy acid is used, these pits have proved very satisfactory. Cement walls cannot be satisfactorily acid-proofed.

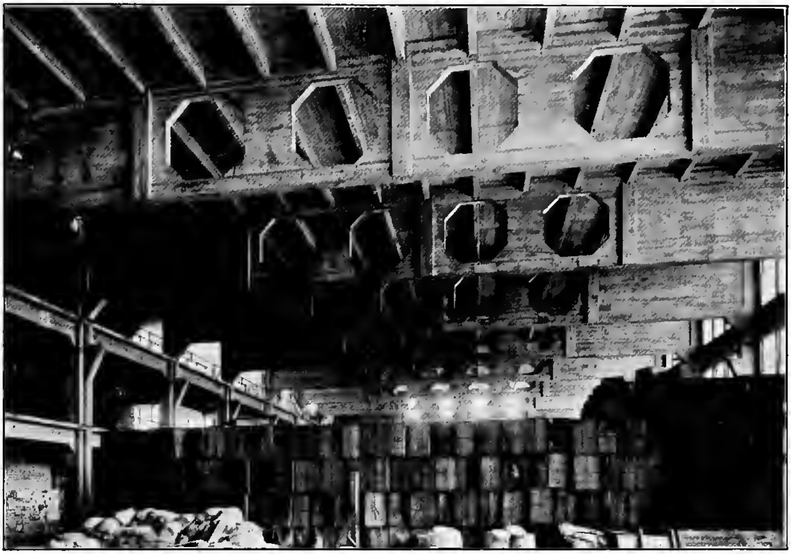

FIGURE 14.—CONCRETE GIRDERS, EIGHTY-FOOT SPAN, IN A RUBBER GOODS STOREHOUSE.

DESIGN OF CONCRETE STRUCTURES.

The subject of design will be briefly covered, and that in a non-technical way. So many tests have been made of beams and girders in laboratory test specimens and in actual work that the theory and practice of design have been thoroughly established and engineers can guarantee results without hesitation. Floors can be built with either beams and girders, beams close together or far apart, as in wood mill design; as well as in the distinctive concrete methods of wide beams with a small panel between, and the straight mushroom or girderless design.

An economical span for ordinary loads as found in the textile industry is from 18 to 22 feet in each direction, making approximately square bays. However, the spacing of columns can be made anything which the conditions demand, from very close together up to very long spans. The longest span ever called to the writer's attention was 106 feet, and this was a roof with 15-foot galleries suspended from it along each side. The longest span built by the writer is 80 feet. From 30 to 50 feet is relatively common, although not as economical as the first named standards.

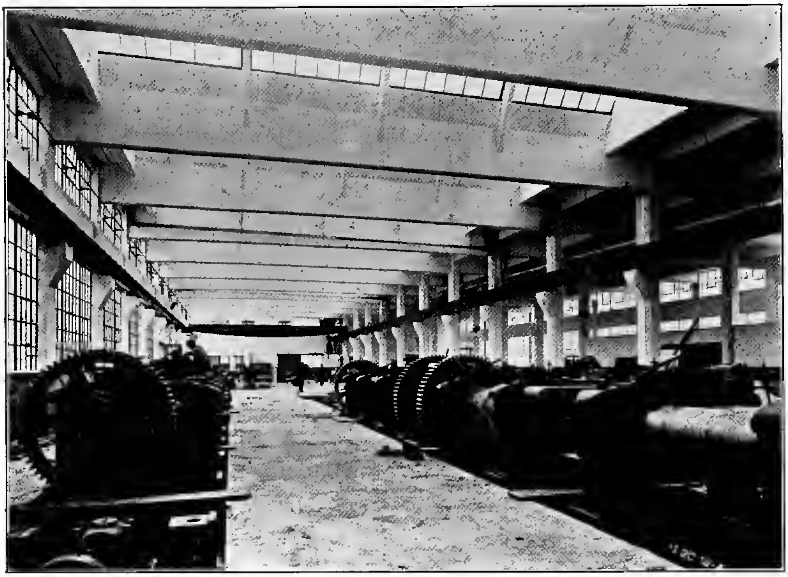

FIGURE 15. —CONCRETE SAWTOOTH ROOF; ALSO CONCRETE OFFSETS TO CARRY RAILS OF TRAVELING CRANE.

The loads which can be carried vary from a light load of 25 pounds for a roof, to a ton to the square foot. Columns can be made plain or reenforced. If the building is high and the loads heavy, to save room it is often desirable to carry the load on a structural steel core which is fireproofed with concrete. For buildings up to four stories, reenforced concrete columns will be found the cheapest; and the size is not objectionable in the lower stories unless the loads are exceedingly heavy. For six stories and more, if the lower story columns are too large, structural steel may be substituted. It is not necessary to use any horizontal structural steel members, as the floors will be supported without difficulty from shelf angles riveted to the steel members. Brackets for crane girders can be easily cast with the concrete columns, where necessary.

CONCRETE FLOOR FINISH.

An important detail of construction is the floor finish. The cheapest finish is granolithic,—a mixture of tough crushed stone and cement, laid either as an integral part of the floor construction or as a second coat following. There are reasons for both types of construction, and the arguments for and against are too long for the limits of this paper. Another very general type is wood. There are various methods of laying this. The first one is to embed sleepers in the cinder concrete fill, to which a single floor is nailed, and sometimes a double floor. Sometimes a plank underfloor is laid, either loose or mopped down with asphalt, on which a finished floor is laid. Another method is the laying of a porous concrete containing cement, sand and asbestos, to which the floor is nailed direct, the nails holding well in the lower coating. The merits and demerits of the different methods are matters of argument.

On top of a concrete floor, the wood can be laid in whatever direction is desired, whereas on wooden frame floor it can be laid only in one direction, which is determined by the framing. The most serious of the objections which have been found with wooden floors laid solid is that they swell and buckle. Sometimes they have risen 30 inches from place. To overcome this, sometimes bolts are embedded in the concrete construction at sufficient intervals to hold the underfloor rigidly in place, and sometimes slots are left to relieve the swelling. It has been found that underfloors embedded solidly in asphalt rot out in a relatively short time.

The most frequent objection to the granolithic floor comes from the operatives, who claim that the floor is hard on their feet and lames them. An extensive study made by the writer some years ago led to the conclusion that the trouble was solely with the fact that granolithic is a better conductor of heat than wood. Operatives wearing thin shoes complained when their feet became cold, and when standing in one place the circulation was impaired and their legs became tired or lame. By the use of heavy shoes, or by standing on a wooden grating, this difficulty is overcome. Complaints are not received from operatives who move about freely in the performance of their work. The advantages of a clean, smooth floor, low in first cost and cheap in maintenance, can thus be had without any objection from operatives.

A dustless floor is one which wears off so slowly and so smoothly that it does not noticeably cause disturbance. The question of obtaining this floor is largely one of selection of the aggregates. A thoroughly first-class aggregate, tough and durable, will avoid most of the trouble caused by dusty floors. The writer has not known any cases where dust has risen sufficiently to be a serious disturbance to machinery.

If the aggregate is bad, not much can be done to correct it. There are, however, various ways of reducing the dust, which comes mostly from the cement, but partly from the stone. A silicate of soda or boiled linseed oil will minimize the trouble. One power-house, built about 1898, had a floor so dusty that, with patience, probably an inch of it could have been swept away. Two applications of boiled linseed oil laid the dust so well that during the next six years of wear there was no trouble whatsoever. The writer has not seen it since then, but presumes it is still in good order.

There seems to be no material which can be put into the surface of a concrete floor and which, while still withstanding wear, is resilient or soft to stand upon. The wear depends upon the quality of the stone. Either one must expect a hard, tough surface, or else use some other substance than Portland cement.

ATTACHING MACHINERY OR PIPING TO CONCRETE FLOORS.

It is an easy matter either to embed inserts in the floor for the attachment of shafting, piping, etc., in a pre-arranged method, or to insert these so that timbers can be bolted to them and allow an elastic method of attachment. Again it is fairly simple to drill holes for the insertion of expansion bolts, where no previous provision has been made. The cost of setting these inserts varies with their style, but for material and labor may be said to run between 5 and 10 cents each. They can be attached as readily to corrugated iron, which is today very extensively used for form work, as to the wooden panels which were used most extensively some years back. Corrugated iron is much cheaper to use for form work than wood panels, and the writer thinks it makes a much better looking ceiling.

The question of relocating machinery can be taken care of under modern conditions. In the weave shed, for instance, if it becomes necessary to change the size of the looms or their arrangement, either the individual motor drive can be adopted or arrangements can be made to locate the new shafting in the most advantageous position overhead. Fastening the machines to the floor in the new arrangement is simply a matter of drilling small holes and using expansion bolts. Cutting holes through the floor for carrying belts from one story to another might be serious, because it would be difficult to arrange the holes in a way to escape cutting reenforcement.

Steam pipes are rarely embedded in the floor. The writer has never known of a case personally. It is quite common, however, to put in conduits for electric wires, and it would be just as easy to insert pipes. The writer believes, however, that the movement of the pipes, with changes of temperature, would be likely to cause trouble, especially if there were bends in the pipe rigidly embedded in the concrete.

Window frames for large areas are made largely of rolled steel sections, sometimes of a single piece and sometimes built up. Both types have their advocates and their individual merits. Actual fire tests have shown that while rolled steel shapes are not as fire resisting as sheet metal formed into a box, yet it is an excellent fire resistant, and unless the fire hazard from an outside exposure is very bad, are good enough. Wire glass is advisable if there is any risk from spreading of fire from story to story, or if there is exposure from without.

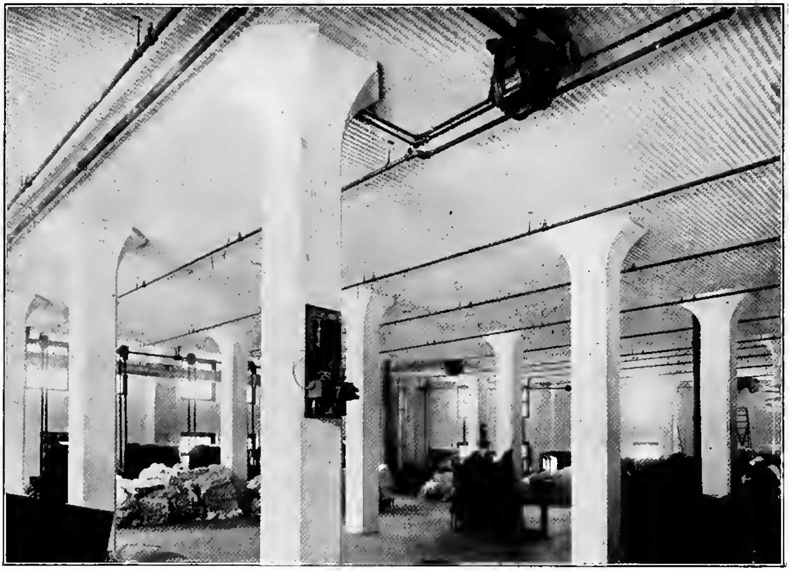

FIGURE 16. — MOTOR HUNG FROM CORRUGATED CEILING IN THE MASSACHUSETTS COTTON MILLS' STOREHOUSE, LOWELL.

Concrete stairs have long since replaced iron, or the combination of iron and stone treads, because they are lower in first cost, non-slipping, and better protection against fire. If desired, safety treads of various types can be permanently attached to the treads, to reduce still further the possibility of slipping.

DURABILITY OF CONCRETE STRUCTURES.

A few of the properties of the material may well be kept in mind in connection with the designing. Steel embedded in concrete is prevented from rusting if the cement is in hard contact with the steel, even though the combination be permanently in a wet place. Cement increases in strength with age. Tests have been carried to seventeen years, which show a measurable increment each year. Concrete setting in air shrinks somewhat, and subsequent expansion due to heat never overcomes the original shrinkage due to setting. Therefore cracks open and remain open, and we shall speak of these as contraction, not as expansion cracks.

By reference to the great conflagrations which have taken place, it will be seen that if concrete is properly made it is one of the best fire resistants which we have. As a resistant to heat, the material of the aggregate is important. The stone should be as near fireproof as possible. A trap is very much better than granite. Doubtless you all know how well a concrete mill storehouse withstood the great Salem conflagration, and the experiences of the recent great fire in the Edison plant are fresh in your minds. This latter developed, we think, the greatest heat to which concrete buildings have ever been subjected, with the greatest apparent injury to them; but it has been found that they could be restored to their original condition for about 13 percent. of their first cost.

A CONCRETE BUILDING IS TRULY MANUFACTURED.

Some attention should be given to methods of construction. It should first be noted that the building of reenforced concrete is a manufacturing proposition. Crude materials, sand, stone, cement and water, are combined with each other, placed in forms which are previously made to hold the plastic material, which is poured around reenforcement previously set and secured in position, and a new material is thus manufactured in place. This is a more difficut proposition than assembling. The building of mill construction is largely that of assembling. One brick is piled upon another with mortar between. Wood is put in place with very little change from its original form. For this reason, a better type of builder is desirable for a reenforced concrete building than for the other. A manufactured article is either right or wrong; there is no half way about it. If it is concrete and if it is wrong, it must either be accepted as it is and remain wrong, or else it must be torn down and done over. Hence the great importance of doing it right the first time.

Modern building has become a scientific process, with a great deal of detail in methods and operation, in order to obtain the maximum of economy; and the day of the bright mechanic who has worked up to be a general contractor is fast passing. The general contractor for this type of work ought to be an engineer. It is very desirable that his job superintendent is an engineer, and many of them are. They should have an intimate knowledge of the theory as well as the practice of design. Points often come up during the day's work which have been overlooked by the designing engineer, and which if not properly covered by the superintendent from an engineering standpoint will fall short of the best results.

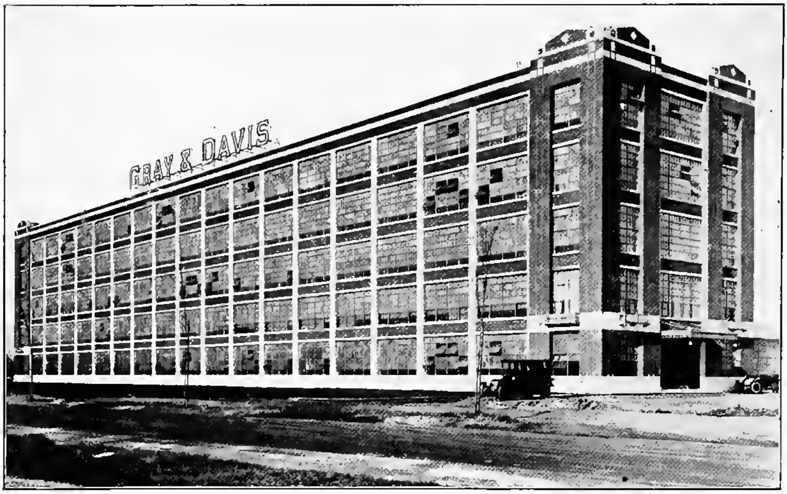

FIGURE 17.—TAPESTRY BRICK USED FOR EMBELLISHMENT OF A MILL.

METHOD OF HANDLING A CONCRETE JOB.

To show briefly the intricacy to which it is necessary to go to get economical results, the writer might mention that a good builder in reenforced concrete today, after long study, has settled upon a type of form which long experience has shown the men can build quickly and economically. Plans of the forms are made to fit the particular building with as much precision as structural steel is laid out in a bridge shop. Panels for columns and beams are drawn out, showing the number, width of boards, the number of cleats, the position, and even the size and number of nails. The first use is located and their second use, when taken down, is planned from place to place through the building, until finally it reaches the storage pile for removal from the site of the finished structure. From these plans the bill of material is scheduled, and when received the material is put in piles pre-arranged, and shown on a ground plan of the lot.

A routing department is established and the materials are moved by written orders and taken to saw mill, where they are cut according to written instructions and moved to benches. Here they are made up from blueprints and are from there taken by instructions to the building, where the experienced carpenter foreman, who is now given freedom to do only that for which he is specially trained, namely, directing his men, sees that the men assemble the work in place with the fewest possible motions and least effort. This seems and is elaborate, but the results are what count.

Although lumber has doubled in price in the last fifteen years, the cost of lumber per square foot of floors has not increased; and although labor has practically doubled in price in fifteen years, the cost per square foot of floors, including all the overhead of making plans, running a routing department, etc., is less than half of what it used to be. This applies as well to reenforcing metal as to forms, and somewhat to the placing of concrete. The greatest savings are obtained where the men work in small units, in pairs, as do carpenters, rather than in the large units necessary in the mixing and placing of concrete.

It has been supposed that the laying of brick has been so well established that few if any savings could be made upon it. But a study of methods during the past year or two, and applying the principles of scientific management, and somewhat the task and bonus, the cost of brickwork has been reduced several dollars per thousand without the slightest sacrifice in quality. This gives the very great advantage of planning the work to be done at a certain speed and place, and enables all the other trades and sub-contractors to co-ordinate their work to a definite schedule, thus saving in time and expense.

COST–KEEPING SYSTEM IN CONCRETE WORK.

An accurate and detailed cost-keeping system is installed on the job, and daily costs are prepared for the use of the job superintendent. Before nine o'clock each day, he knows the complete record of yesterday's costs, and immediately goes upon the work to straighten out the cost of those items which may be high. Charts are placed on the wall, where at a glance it is seen whether the actual work is running above or below that which it was estimated it should cost before the work started.

The sub-foremen and gang bosses take a keen interest in watching these, which leads them to think and work for low costs. The general superintendent encourages them in this, and insists that there shall be no sacrifice of quality to obtain these results. These methods have been amply justified. A dollar spent in the drafting room or cost-accounting department has saved many dollars outside, and the combination of the direct and indirect cost is much lower than it used to be. This precision also saves in the time of construction.

SPEED OF BUILDING IN CONCRETE.

Assume the very common case where a manufacturer delays an increase until the last moment, then wants his mill in the shortest possible time. Frequently orders for a mill are placed before a single plan is made for the building. In a week's time the mechanical plant is collected, the general plans of the building laid out, the details of the footings and foundations completed, the general method of operation studied out, and a time study of operations made as far as the sweeping out of the finished building. Material is scheduled, and ordered to be delivered in a pre-arranged order and at times as wanted, and in a week from receipt of order the organization starts on the ground.

In general, a four-story mill requires from three to four weeks for foundation work, the frame will be erected at the rate of a story a week, and in from four to six weeks from the casting of the roof the job will be finished and delivered. Thus the whole undertaking can be put through economically in four months as a general average. If greater speed is required it can be made at the sacrifice of economy. Within a few months the writer has erected one four-story and basement mill for occupancy in sixty-two days, and another, under more trying circumstances in mid-winter, in seventy-seven days. The ground area of the building has little influence on the time of construction. This is governed by the height, as one operation must follow another in height; while on plan it is a question of one mixing plant or two or more, and of the number of men to operate them properly.

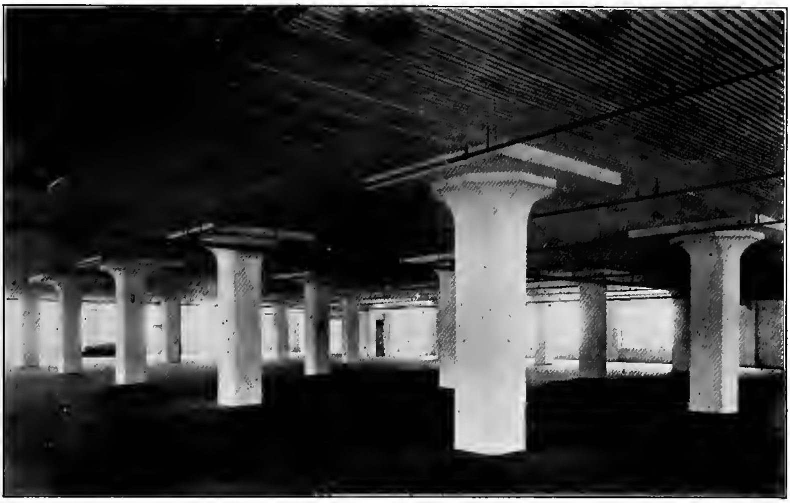

FIGURE 18.—CORRUGATED CEILING SHOWING USE OF CORRUGATED STEEL FORMS. ALSO THE USE OF MUSHROOM FLOORS, AND OF INSERTS TO CARRY PIPING.

COST OF CONCRETE CONSTRUCTION.

Lastly, in regard to relative cost of a reenforced concrete fireproof mill and one with brick walls and wooden floors, the former used to cost about 15 per cent. more on the average. As improved methods have been developed in the handling of men and materials on reenforced concrete, the prices have more nearly approached one another. In a number of cases they meet, and in a few cases the reenforced concrete building is cheaper in first cost, in addition to the other advantages above enumerated. The destruction of our forests of southern pine of large dimension, making this material more scarce and of inferior quality, has been a marked element in the change.

WHY OWNERS DEMAND FIREPROOF BUILDINGS.

Perhaps the most important reason why manufacturers are building of fireproof construction today is to insure a continuity of their market. If, as many do, they sell under a special trade mark, and this is off the market for a number of months, it is difficult to recover the lost ground. The building and contents may be insured; the market cannot.

Lithomount
~~Pamphlet~~
Binders
Gaylord Bros. Inc.
Makers
Syracuse, N. Y.
Pat. Jan. 21, 1908